Federal Railroad Administration
Signals and Train Control
Fact Sheet

Background on Non-Signaled Versus Signaled Rail Lines

There are two basic types of rail lines, or territories, over which the nation's passenger and freight trains operate, non-signaled and signaled. On lines equipped with signal and/or train control systems, there are four basic types of configurations that provide for the safe movement of rail traffic. Each type of signaled system has a successively higher level of functionality and redundancy which builds upon the previous with additional layers of safety. Approximately 60 percent of the nation's mainline tracks are equipped with some type of signal and/or train control system, and nearly 80 percent of all rail traffic operates over those signalized routes.

Non-Signaled / Dark Territory

Train movements within non-signaled or "dark territory" are controlled by dispatchers who authorize or instruct locomotive engineers, usually through radio communications, to move a train from Point A to Point B and then await further instructions. The dispatcher keeps a written record of the authorities issued and is responsible for ensuring that only trains that have been given authority to operate within a given area do so during specified timeframes. Train crews report to the dispatcher when they have moved through and clear of an area so that authority to safely operate over that same portion of the rail line can be given to a different train. This process minimizes the risk of two or more trains occupying or operating over the same stretch of track simultaneously in such a way that they might collide. Only a relatively small number of passenger trains operate in dark territory. The maximum allowable speeds within non-signaled territory are 49 mph for freight trains and 59 mph for passenger trains.

Signaled Territory with Wayside Signals

There are three basic types of wayside signal systems: Automatic Block Signal (ABS), Interlocking (INT), and Traffic Control System (TCS) commonly called Centralized Traffic Control (CTC). On rail lines equipped with these systems, wayside signals located along the tracks generally display indications to a train operator to either proceed (continue operating at maximum allowable speed), slow down (continue movement while slowing and preparing to stop at the next signal), or stop (before passing the signal). These indications are commonly displayed by illuminated green, yellow, or red aspects respectively (or an equivalent scheme including some that are not colored) in much the same manner as roadway traffic signals inform motorists whether it is safe to proceed.

The primary difference between these three types of signal systems is whether they provide direct authority (i.e. permission) for train movements instead of merely providing a supplemental indication to that authority. The signal displays or indications of an ABS system do not actually provide a locomotive engineer with authority for train movements but rather supplement another form of permission. For example, in a territory equipped with an ABS system, a verbal authority is given by the dispatcher for a train to proceed from Point A to Point B, as in non-signaled territory. However, the area is also equipped with wayside signals which provide information regarding: rail integrity (broken or missing rail), train occupancy (a train in the "block" or section of track governed by the signal), and/or the position of track switches in the block. INT and TCS signal indications actually provide the authority for train movement along with the protections described above.

In ABS territory, the signals are triggered automatically by the approach of a train operating over a particular stretch of track. These signals are actuated in a first come first serve manner, with the authority for the train to be there granted by a verbal command to the train crew given by the dispatcher, with repeated verbal confirmation back from the train crew to the dispatcher. In INT areas, the signals may be actuated automatically, through direct control by a dispatcher, or through a combination of the two. In TCS territory, the signals at each control point are managed directly by a dispatcher and there may be one or more “automatic signals” placed along the stretch of track between the dispatcher-controlled signals at adjacent control points. In some types of INT and within all areas of TCS, the authority for train movements is channeled through the dispatcher to a train crew via the indications of the wayside signals that the dispatcher directly controls.

At controlled points within TCS, and at certain INT locations, dispatchers can control routes for specific trains; remotely control track switches to be operated in proper sequence; and, control signals to display the desired proceed indications. TCS technology utilizes vital wayside signal system logic to ensure that route integrity is preserved and appropriate timing is provided prior to signals displaying proceed indications in order to keeps trains apart. In signaling sequence, one or more “approach” signals warn locomotive engineers of trains to slow in case the track ahead is occupied by another train or a switch is aligned for a “diverging” route ahead (that most likely requires a slower speed movement), or on approach to the next signal requiring a stop (perhaps because the track ahead is occupied by another train). “Absolute” signals (at controlled points in TCS and at INTs) are capable of displaying stop indications (a point that a train may not pass until coming to a complete stop, and the train crew receives explicit verbal permission from the dispatcher that it is safe to proceed).

The type of wayside signals described above normally function with a very high degree of reliability providing a significant margin of safety. However, if a locomotive engineer is distracted, misperceives or ignores a signal indication, he/she may operate the train above the maximum allowable speed and thus be unable to stop when required.

Cab Signals and Automatic Train Stop/Automatic Train Control

Cab signals supplement wayside signal systems by providing locomotive engineers a continuous visual display of the current signal indication inside the locomotive cab. Cab signals are normally augmented by either an automatic train stop (ATS) or automatic train control (ATC) function. In ATS systems, the brakes will automatically be applied to bring the train to a stop if the engineer fails to acknowledge a more restrictive signal indication (i.e. an indication to slow down). However, if the engineer actively acknowledges the signal indication, the ATS system will not engage the brakes, and the train will slow down or come to a stop only if the engineer takes appropriate action. On the other hand, for ATC systems, an automatic brake application will occur to bring the train to a stop if the engineer fails to acknowledge a more restrictive signal indication, or fails to take action to actually reduce the speed of the train as required by the signal indication.

Most of the rail lines that host intercity and commuter passenger operations in the Northeast, and other locations where both passenger and freight trains operate, use cab signals. Cab signals coupled with train control capabilities provide “automated enforcement” that is highly effective in correcting errors by train operators. However, these systems are typically not capable of automatically stopping a train approaching an absolute signal displaying a full stop indication if the engineer has already reduced the train’s speed below a pre-established level (normally 15 or 20 mph).

Positive Train Control (PTC)

Positive Train Control (PTC) is a generic term and it refers to a set of fully integrated technologies that can automatically enforce speed restrictions, prevent over-speed derailments and train-to-train collisions, and protect roadway workers within specific railroad work zones. Such systems require active train location detection and tracking capabilities, computer networking technologies, software that accurately calculates braking distances for different types of trains, and a reliable wireless communication network to link all of these operating elements and system components.

Train control systems providing full PTC functionality are in place on portions of the Northeast Corridor where trains operate at 125 mph or higher, and on Amtrak's line in Michigan on which its trains operate at speeds up to 95 mph. The chart below provides information on the current location of various types of PTC systems in operation or undergoing testing.

FRA Efforts to Foster PTC Development and Implementation

The Federal Railroad Administration (FRA) has long supported the development and deployment of PTC technology and continues to facilitate its implementation across the nation's rail system. A brief history of those wide-ranging actions and efforts are summarized below.

- In 1994, an FRA report titled, *Railroad Communications and Train Control* introduced the term "positive train control" (PTC) and effectively approved advance train control system specifications developed by the Association of American Railroads (AAR) during the 1980s.

- In 1997, FRA's Railroad Safety Advisory Committee (RSAC) created a PTC Working Group, which determined the term PTC refers to specific safety objectives, not specific technology.

- In 1999, an RSAC report titled *Implementation of Positive Train Control Systems* identified specific steps to be taken by the government and industry to facilitate PTC development. Also, FRA worked with CSX Transportation on development of its Communication-Based Train Management System. And, FRA's Next Generation High-Speed Rail Program, the Illinois DOT, AAR and others partnered on the North American Joint PTC Project to test and demonstrate an integrated signal and train control system with full PTC capabilities.

- In 2004 FRA initiated a study of the costs and safety benefits of PTC which determined that implementation costs for 100,000 miles of track are estimated to be in excess of $2.3 billion.

- In 2005 FRA's revised federal signal and train control regulations took effect setting forth the functional requirements and operational parameters necessary to achieve PTC safety objectives.

- In 2006, FRA approved the BNSF Railway's Electronic Train Management System (ETMS) for non-signaled and single-track traffic control territory, the first PTC system developed under FRA's revised rules that established performance standards for such systems.

- In 2008, FRA gave approval to Chicago's METRA commuter railroad to field test a variant of the ETMS system to provide the location of crossovers and associated speed limits.

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Location of Positive Train Control (PTC) Systems and Technology Demonstration Projects October 2008

State Location	RR	System Name	Route Miles(1)	Track Miles(2)
MA, RI, CT, NJ	Amtrak	**ACSES/ATC**	177	376
DE, MD NY, NJ	Amtrak PATH	**ACSES/ATC** CBTM	27 14	54 43
OH	OCRS	Train Sentinel	356	356
SC, GA, TN	CSX	CBTM	273	273
SC	NS	OTC	120	120
MI	Amtrak	ITCS	74**	84**
IL	UP	NAJPTC#	120	120
IL	BNSF	ETMS I	132	132
IL	METRA	ETMS	34	75
TX, OK	BNSF	ETMS II	205	217
NE	UP	CBTC-VTMS	175	367
AK	Alaska	CAS	531	541
WY, WA, ID	UP	CBTC-VTMS	168	198
ND, MT	BNSF	ETMS I*	153	153

Acronyms for PTC Systems in Chart
ACSES/ATC - Advanced Civil Speed Enforcement System/Automatic Train Control- Fully operable
CBTM - Communication Based Train Management system (including on both CSX and PATH)
OTC - Optimized Train Control system
ITCS - Incremental Train Control System
NAJPTC - North American Joint Positive Train Control system
ETMS I - Electronic Train Management System configuration I
ETMS II - Electronic Train Management System configuration II
CBTC-VTMS - Communication Based Train Control-Vital Train Management System
CAS - Collision Avoidance System

Footnotes to Chart
(1) Right-of-way miles, which may contain several tracks.
(2) Miles of actual track.
This system moved to the Transportation Technology Center, Inc., at Pueblo, CO, for further development.
Currently in revenue service, supporting speeds up to 150 mph. Two additional ACSES segments, engineered but not funded, are not included.
* Upon planned installation on BNSF's Hettinger Subdivision.
** Assuming that ITCS is extended another 8 miles to the Indiana State line. ITCS is currently installed on 66 route-miles (76 track-miles). ITCS track-miles include six controlled sidings, totaling 10 miles.